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The Greatest Medical
Discovery of the present Century.

PROF. KOCH'S CURE FOR CONSUMPTION

Clearly explained for the General Reader

BY

DR. H. FELLER,

PHYSICIAN (BERLIN).

With Life and Portrait of
Professor Koch.

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PROFESSOR ROBERT KOCH.

PROFESSOR KOCH'S
CURE FOR CONSUMPTION
(TUBERCULOSIS).

POPULARLY EXPLAINED.

BY DR. H. FELLER,
PHYSICIAN, OF BERLIN.

*WITH A PORTRAIT OF PROFESSOR KOCH,
AND A SUMMARY OF HIS CAREER AND SERVICES.*

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PROFESSOR KOCH'S CURE FOR CONSUMPTION.

INTRODUCTORY.

IN breathless suspense the world, during the last few weeks, has been listening for the report that should give information of the progress of Dr. Koch's investigations concerning the curability of pulmonary phthisis. The shadows which every great event casts before it, appeared portentously in this case also;—drop by drop, and scantily at first, communications began to trickle into the press, from the laboratory in the Kloster-Strasse (the Hygienic Institute). The dim indications gradually took more definite forms, and were followed by official communications on the part of those physicians who were commissioned by Koch to test, in clinical and domestic practice, the new method of healing. At length Professor Koch himself has spoken, and has made known to the whole civilised world, by publication in the German

medicinal weekly paper ("Medieinisehe Wochenschrift"), the result of his laborious investigations.

In view of the enormous interest which every individual naturally takes in this advance in the healing art, an advance entirely unforeseen, and at first looked upon with seepitcal unbelief—in view of the universal outburst of astonishment of the medical faculty and laymen alike concerning this marvellous fairy tale that, at the close of the year 1890, had become a distinct reality—it seems to be but right and proper that the non-medical public should receive information, not only with regard to the final result, but also concerning the method by which that result was reached. The author of the present treatise has accordingly set himself the task of presenting to outsiders who do not possess scientific preparatory knowledge, as clear an exposition as possible of Koch's discovery.

HOW PROFESSOR KOCH DISCOVERED. THE TUBERCLE-BACILLUS.

For the beginning of the chain of scientific experiments and observations, whose last and most important link has been added by the latest discovery, we must go back to the year 1882. On the 24th of March in the above-mentioned year, at a sitting of the Physiological Society in Berlin, Koch made a report of the numerous investigations in which he had been, up to that time, engaged—

investigations which threw light upon the origin and nature of pulmonary phthisis (tuberculosis).

Various investigators, as Villemin, Klebs, and Cohnheim, had already proved that pulmonary consumption (phthisis pulmonum) could not be a simple inflammatory (catarrhaic) disease, but that it belonged rather to the category of infectious diseases—namely, to the diseases that are communicable and contagious. This conclusion had been arrived at by inserting minute portions, taken from consumptive lungs, under the skins of animals, such as rabbits and guinea-pigs; in all these animals pronounced pulmonary consumption was, after a short time, developed. When the communicability of pulmonary consumption had thus been proved, the next object was to find out what was the diseased matter that was communicated—to identify the infectious or contagious matter. And here it was that Koch applied the lever of his investigations. Like others, he recognized the communicability of pulmonary consumption; but he further demonstrated that in the fragments of lung which he inserted under the skin of the animals experimented on, and also in the diseased lungs of the creatures thus inoculated, there could be detected, by means of the microscope, in every case, a quite special kind of fungi shaped like tiny rods—these were *bacteriæ*, or *bacilli*. From the little pieces of lung used for inoculation, and also from the diseased lungs of the inoculated animals, Koch now took very

minute particles, selecting exactly those places in which the fungi appeared in greater numbers. These minute particles he spread upon certain substances—meat-broth, gelatine, or upon the cut surface of a potato. To use a familiar illustration : just as the mould-fungus readily spreads itself on the damp wall of a cellar, so did the little rod-fungus develop itself in the meat-broth contained in a reacting glass, or on the potato ;—to use the technical expression, the bacilli found in the above-named substances a congenial soil.

As yet, however, these fungous growths were not pure, but mingled with other constituents, that adhered to them, and consisted partly of other kinds of fungi. Then Koch again took small particles from these fungoid growths, and transplanted them to another hotbed, where they developed themselves anew. The same process was repeated until a growth had been produced consisting exclusively of bacilli, without any foreign admixture. Thus a "pure culture" of bacilli had been obtained. With bacilli thus freed from all mixture of foreign substances Koch then inoculated a number of animals—guinea-pigs, dogs, and rats ; and, behold, within a short time there was developed in all of them distinct tuberculosis of the lungs, as well as tuberculous disease in other organs—the liver and spleen. The proof had thus been obtained, that these bacilli are not only the companions of pulmonary consumption (*phthisis pulmonum*), but that they must also be looked upon as the con-

veyers of the infecting matter, as *the parasitic cause of that disease*. Accordingly, from that time these bacilli have been designated "tubercle-bacilli."

It was at once manifest that this discovery would have a great influence upon the recognition and treatment of this terrible disease. The difference between the views formerly prevalent concerning it and those now held is strikingly set forth in the following words, with which Koch himself already at that time worked out the problem of hygienic science for arresting the spread of pulmonary consumption :—

"Until now it has been the custom to regard tuberculosis as the outcome of social misery, and in the alleviation of that misery to hope for a diminution of the disease. Consequently, measures definitely directed against tuberculosis itself are yet unknown in medical science.

"But in future, in the combat against this terrible scourge of the human race, we shall no longer have to do with an indefinite 'something,' but with a formidable parasite whose conditions of life are to a great extent known and can be still further ascertained. The fact that *this parasite can find the conditions of its existence only in animal bodies*, and cannot, like the bacilli that occur in mortification of the spleen, thrive outside the same, under ordinary natural conditions, affords *especially favourable prospects for results in the combating of tuberculosis*."

THE PROGRESS OF EXPERIMENTAL INVESTIGATION.

In fact, the long period of indifference in the treatment of pulmonary consumption was now followed by a time of the most active attention and industry; and this industry was principally directed towards measures that, so far as might be, should prevent the spread of the disease. As tubercle-bacilli were found, sometimes in greater, sometimes in smaller numbers, in the expectorations of persons suffering from disease of the lungs, endeavours were made to render this expectorated matter as far as possible harmless; and the sick people were gradually trained to the habit of not spitting at random, in whatever place they happened to be—in the dwelling, the hospital, or the cattle stable—but to eject the matter into spittoons, where it could be disinfected by a solution of carbolic or sublimate; for five per cent. of carbolic or one thousandth of sublimate solution killed the bacilli and rendered the matter innocuous.*

Moreover, by the introduction and continual

* The unscientific reader would naturally think that the above-mentioned substances could also be used as healing agents in combating pulmonary consumption; but, introduced into the bodies of men and animals, they act as virulent—even as deadly—poisons, so that their employment as therapeutic agents is out of the question. The same objection holds good concerning boiling water, which likewise kills the bacilli.

extension of a compulsory inspection of meat, the sale of diseased beasts was rendered first difficult and afterwards impossible. For lung disease in cattle is identical with pulmonary consumption in human beings. Milk supplied for sale to the public was especially subjected to a stricter police supervision ; with regard to the possibility of its having come from cows suffering from disease of this kind.

Finally, the families of persons suffering from lung-disease were cautioned against too close a contact with the patients, and to avoid kissing them on the mouth, and using the same glasses and other eating and drinking utensils, or the same towels with them.

But attention was now directed not only to preventing and hindering the spread of pulmonary consumption ; real methods of curing the disease were now sought.

The actual results did not, however, correspond to the energy with which the work was undertaken. Balsam of Peru, preparations of tar, creosote, " Iodoform," and other means were applied, internally and externally, for combating the disease, the most varied agents were used for inhalation, and, finally, the attempt was made to kill the bacilli in the lungs themselves, by the breathing in of heated air. Some of these healing methods, as, for instance, the last-named, the heated-air method, vanished from the horizon as quickly as they had appeared. With others, on the contrary, real results were obtained, especially with the adminis-

tration of creosote, which in a great many cases of pulmonary consumption has exercised a decidedly beneficial influence on the disease, and has frequently even led to a cure. But all these attempts and experiments were but a groping in the dark— attempts that were destitute of any decided system or aim ; consequently, in the absence of any firm scientific support, none of these means succeeded in obtaining an entirely satisfactory footing in the medical world ; and it may be rightly said that only temporarily, now this method and now that, had a slight influence on the sick-bed treatment of patients by medical men. Meanwhile, the man who was destined to discover the key to the dark entrance-gate through which the way led to the noble structure of a scientifically-supported method of cure for consumption, worked on perseveringly and with his object well before him, far from the turmoil of the world, in his quiet laboratory.

PROFESSOR KOCH'S EXPLANATION OF HIS GREAT DISCOVERY.

On the 4th of August, 1890, at the first sitting of the Tenth International Congress in Berlin, Robert Koch, in the presence of an audience numbering several thousands of native and foreign physicians, and of the Minister of Instruction, Von Goslar, delivered an address, " On Bacteriological Investigation ;" and in this address, which everywhere excited the greatest interest, he for the first

time disclosed to his astonished hearers the results of his latest investigations on the curability of tuberculosis. He informed them that for years he had been seeking after methods which could be therapeutically employed against that disease. In this endeavour he had struck out an entirely different path from that pursued by other men of science, who, like himself, had been engaged in attempts of that description.

He had not begun his experiments with the human subject, but made the starting-point of his attempts with the carriers of the disease, the tubercle-bacilli themselves. In the first place, he sought and found means which hindered, or even completely arrested, the growth of the bacilli in the nests or hotbeds mentioned above; and here, also, he did not at once choose men and women as objects of experiment, but tried, in the first instance, on animals, if the observations he had made on the reacting glass (in which are the substances whereon the bacilli develop themselves) also held good with respect to the living bodies of animals.

A very great number of substances were then tested to ascertain what influence they exercised upon tubercle-bacilli produced in a pure condition by cultivation; and the result showed that not a few substances were capable of preventing the growth of tubercle-bacilli. It was not necessary that a method should effect more than this. The lecturer demonstrated how it was not at all requisite that

the bacilli should be killed in the body, but that it would be sufficient to render them harmless to the body, if their growth and multiplication were prevented. As such restraining means, even when used in small doses, a number of volatile oils, some tar colours, especially methylene blue and aniline yellow, etc., and, among metals, quicksilver in the form of vapour, mixtures of silver and gold, were found efficient, and cyanides were especially noticeable by far surpassing all other substances in the effect they produced. Reduced to a proportion even of from one to two millionths, they kept back the growth of tubercle-bacilli. But all these substances showed themselves utterly ineffective, so soon as they were tried upon tuberculous animals.

Notwithstanding all failures, Koch would not let himself be deterred from further researches to find methods for checking the development; and at the close of his address, which was listened to with the greatest interest and expectation, he made the following declaration:—

“Finally, I have come upon substances which are capable of stopping the growth of tubercle-bacilli, not only in the reagent glass but in the animal body. All investigations concerning tuberculosis are, as any one who has experimented on the subject must have sufficiently found, very lingering. Thus, my attempts with these substances are not yet concluded, though they have occupied me for almost a year; and I can only

impart this much concerning them, that guinea-pigs, which are known to take tuberculosis very readily, are no longer affected by inoculation with tuberculous virus (poison), after having been first subjected to the action of one of these substances ; and that in cases of guinea-pigs, where general tuberculosis has already been developed in a high degree, the process of disease can be brought completely to a standstill, while the means employed will not, in other respects, produce any deleterious effect upon the body."

KOCH APPLIES HIS DISCOVERY TO THE HUMAN BODY.

Thus Koch had discovered a remedy which, introduced into the body of an animal, rendered harmless the tubercle-bacilli that were present therein, without in any way acting prejudicially upon the health of that body in other directions.

The next thing to be done was to repeat these experiments upon the human body ; and of the brilliant results of these experiments an account is given in the latest public communication of Koch, in the extra edition of the German medical weekly journal ("Deutsche Medicinische Wochenschrift") of the 13th of November, 1890. The contents of the treatise that appeared in this number, entitled, "Further Communications respecting a Curative Process against Tuberculosis,

by Professor Koch, Berlin," we here reproduce *verbatim* :

In an address which I delivered a few months ago in the International Medical Congress, I made mention of a means capable of rendering the animals experimented upon unsusceptible of inoculation with tubercle-bacilli, and of bringing the process of tuberculous disease to a standstill in animals already suffering from it. Since that time experiments have been made with this means, on the human subject, and of these experiments I shall speak further on.

In reality it was my intention, definitely to conclude the investigations, and especially to obtain a greater amount of experience on the application of this method in practice, and its nature generally, before making public any facts concerning it. But in spite of all precautions taken, so much of it has got into circulation, and, indeed, in a distorted and exaggerated form, that it is incumbent upon me to prevent the spreading of false ideas on the subject, by putting forth an explanatory review of the matter, as it stands at the present moment. Certainly, under existing circumstances, the exposition can be only a brief one, and must leave open many important questions.

The experiments were carried out, under my direction, by Dr. A. Libbertz, and Staff-Physician Dr. E. Pfuhl, and are to some extent still going on. The necessary morbid material has been placed at

our disposal by Professor Brieger from his general clinical practice, by Dr. W. Levy from his surgical private clinical practice, by Privy - councillor Fränzel and Chief Staff-Physician R. Koehler from the *Charité* Hospital, and by Privy-councillor V. Bergemann from the surgical clinic department of the University. To all these gentlemen, and to their assistants, who have given their services in the experiments, I desire, at this opportunity, to offer my sincerest thanks for the active interest they have taken in the subject, and the disinterested readiness with which they have helped me. But for this manifold co-operation, it would have been impossible to carry the difficult and responsible investigation so far as it has been carried within a few months. •

As my work is not yet concluded, I cannot here give particulars of the origin and preparation of the remedy employed, but must leave these to be made in a future communication.*

The remedy consists of a brownish, clear liquid, which is sufficiently durable in itself, and therefore does not require any special precautions

* "Those physicians who are desirous of making experiments at once with the remedy, may obtain it from Dr. A. Libbertz (Berlin, N.W., Lüneburger-strasse, 28 II), who has undertaken the preparation of the remedy, with my co-operation, and Dr. Pfuhl's. But I must observe that the supply on hand is a very limited one, and that it will be some weeks before larger quantities are available."

in the keeping. But before it can be used, this liquid must be more or less diluted; and the diluted preparations, if they have been made with distilled water, are liable to decomposition. Bacterian growths are quickly developed in them; they become turbid, and then useless. To prevent this, the dilutions must be rendered sterile by heat, and preserved in wadding, or what is more convenient, they should be prepared with an admixture of 5 per cent. of phenyl. But frequent heating, and also the mixing with phenyl, the effect seems to be weakened, especially in preparations that have been much diluted; and I have accordingly, always, as far as possible, made use of solutions freshly prepared for each occasion.

The remedy does not work by means of the stomach; to yield an undoubted result it must be administered by subcutaneous injection. In our operations we exclusively employed the syringe specified by me as suitable for bacteriological work; the squirt furnished with a little india-rubber bladder, and without a piston. A syringe of this kind can easily and certainly be kept in an aseptic condition by being rinsed out with absolute alcohol; and to this circumstance we ascribe the fact, that in more than a thousand subcutaneous injections not a single abscess was caused.

As the fittest place for the application, after some trials with other parts, we selected the skin of the back between the shoulder blades, and in the region of the loins; because the injection in

those regions produced the smallest amount of local reaction (as a rule there was none at all), and was almost entirely painless.

*KOCH EXPLAINS HOW THE REMEDY
OPERATES ON THE HUMAN SUB-
JECT.*

With regard to the action of the remedy upon the human subject, it became visible at the very outset of the experiments, that in a very important point, the human being is affected by the remedy in a manner very different from the animal generally used for experiments, the guinea-pig. In this we have a confirmation of the rule that cannot be sufficiently impressed upon the investigator—namely, that a conclusion must not necessarily be drawn, from an experiment on an animal, that the same manifestations would appear in the case of the human subject.

As a matter of fact, mankind are much more susceptible to the operation of the remedy than is the guinea-pig. Up to two cubic centimetres, and even more, of the diluted liquid may be subcutaneously injected in a healthy guinea-pig, without affecting it in an appreciable degree. In the case of a healthy adult person, on the other hand, 0.20 centimetres will be sufficient to produce an intense effect. Proportionally to the relative weight of the bodies, it may be asserted that $\frac{1}{13000}$ of the quantity that produces no appreci-

able effect on the guinea-pig calls forth a very marked one in a human being.

The symptoms which arise in a man after the injection of 0·25 cubic centimetres, I have noted in myself after an injection made in the upper part of my arm. They were briefly as follows: Three or four hours after the injection, came pains in the limbs, exhaustion, inclination to cough, difficulty in breathing increasing rapidly. In the fifth hour an unusually severe fit of shivering set in, which lasted almost an hour. It was accompanied by nausea, vomiting, and a rising of the temperature of the body to $39\cdot6^{\circ}$ (R.). After about twelve hours all these complaints decreased. The temperature became lower, and by the next day had sunk to its normal point; heaviness in the limbs, and a feeling of exhaustion continued for some days, and for the same space of time the spot where the injection had been made, remained a little painful and red.

The lowest limit for the efficiency of the remedy lies, in the case of a healthy man, at about 0·01 cubic centimetres (equal to one cubic centimetre of the dilution to one hundredth); this has been shown by numerous experiments. In most persons the action of this dose appears only in slight pains in the limbs, and a weariness that soon passes by. With some there was in addition a slight rise in the temperature, up to 38° (R.), or a little beyond.

While with regard to the effect of the dose of

the remedy (calculated according to the weight of the body) there is a considerable difference, as shown in man and the lower animals, on the other hand, in certain qualities a remarkable agreement is displayed.

The most important of these qualities is *the specific action of the remedy on tuberculous processes, of whatever description they may be.*

The action on animals in this respect, I will not further describe here, as it would lead us too far; I will at once turn to the very remarkable action seen in the tuberculous man.

THE REACTION: ITS PROGRESS AND SYMPTOMS.

In a healthy person, as we have seen, there is no reaction upon a dose of 0.01 cubic centimetres, or only an unimportant one. Exactly the same thing holds good, as has been proved by frequent experiments, for sick persons, providing they be not tuberculous. But in the case of tuberculous persons the circumstances are completely altered. If the same dose of the remedy, 0.01 cubic centimetres, is injected in one of these,* a strong general reaction, as well as a local reaction, is produced.

* To children of from three to five years we have given a tenth of this dose, namely, 0.001 cubic centimetres, and to very weakly children only 0.0005 cubic centimetres, and have produced a vigorous reaction, but not one that created any alarm.

The general reaction consists in an attack of fever, which, usually beginning with a shivering fit, raises the temperature of the body above 39° (R.) and in many cases to 40° , and even to 41° (R.), besides this pains in the limbs are developed, with tendency to cough, great exhaustion, often nausea and vomiting. In some instances, a light reddish colouring, and in a few cases, also, the appearance of an eruption resembling measles on the breast and neck were observed. The attack begins, as a rule, four or five hours after the injection, and lasts from twelve to fifteen hours. Exceptionally, it may also set in later, and then passes off with little intensity. It is remarkable how little the patients are exhausted by the attack. So soon as it has passed off, they feel comparatively well, generally, indeed, better than before it.

The local reaction can be best observed in those patients whose tuberculous affection is plainly visible; for instance, in those suffering from lupus. In these cases, alterations occur, which display the specifically anti-tuberculous activity of the remedy in quite an astonishing manner. A few hours after the injection has been made under the skin of the back, consequently, at a point quite distant from the seat of the diseased skin in the face, &c., the lupous places, generally even before the commencement of the shivering fit, begin to swell, and to become reddened. During the fever, this swelling and

reddening continue to increase, and may in the end attain a high pitch, so that the network of lupus at various places turns brownish-red, and becomes necrotic. In sharply defined patches of lupus, the highly swollen and brownish-red coloured places were frequently surrounded by a whitish rim almost a centimetre in breadth, which again was hemmed in by a broad border of a high red colour. After the decline of the fever, the swelling of the lupous places gradually subsides, so that it may have disappeared after two or three days.

The lupus centres themselves become encrusted with exuding serum, that dries by the action of the air. They are converted into scabs, which fall off after two or three weeks, and sometimes, after only one injection of the remedy, leaving behind them a smooth red scar. Generally, however, several injections are necessary for the complete removal of the lupous network; but of this we shall speak later on. It must be mentioned, as especially important in this process, that the changes I have designated are entirely confined to those parts of the skin affected by lupus; even the smallest and hidden cores in the network become subjected to the process, and are made visible in consequence of the swelling and of the change of colour; while the succeeding network of scars, in which the lupus changes have entirely run their course, remains unaltered.

The experience gained by watching a sufferer from lupus under treatment with the remedy, is so

instructive, and must at the same time be so convincing as to its specific nature, that everyone who intends to occupy himself with the remedy should, if it is at all possible, begin with a lupous patient.

LOCAL REACTION WHERE TUBERCULOSIS IS PRESENT.

Less striking, but nevertheless appreciable to the eye and touch, are the local reactions in tuberculosis of the lymphatic glands, the bones and joints, etc., in which swelling, increased pain, and likewise a reddening of the parts on the surface are observed.

The reaction in the internal organs, especially in the lungs, on the other hand, cannot be subjected to observation; unless, indeed, the increased cough and expectoration seen in patients with disease of the lungs, after the first injections, be ascribed to a local reaction. In such cases, the universal reaction predominates. Nevertheless, it must be assumed that here also changes are accomplished similar to those that can be directly observed in lupus.

The appearances of reaction above described became manifest wherever a tuberculous process was present in the body, in every case, in the experiments hitherto made, after administering the dose of from 0.01 cubic centimetres; and I consider accordingly, I am not going too far if I assume

that the remedy will in future be constituted an *indispensable* assistant in diagnosis. It will be practicable, by its means, to make a diagnosis in doubtful cases of incipient phthisis, even when it is not possible, by the finding of bacilli or of elastic fibres in the expectorations, or by physical investigation, to come to a certain conclusion as to the nature of the suffering. Glandular affections, concealed tuberculosis of the bones, doubtful tuberculosis of the skin, and similar affections, will be easily and surely recognised and identified. In apparently arrested cases of tuberculosis of the lungs or joints, it will be ascertainable whether the process of disease has really come to a termination, and whether there are not still certain centres in which a spark smouldering amid the ashes might not once more spread the fire around.

REMARKABLE EFFICACY OF THE REMEDY.

Far more important than the capabilities of the remedy for use for diagnosing purposes, is its efficacy as a curative agent.

In the description of the changes which a subcutaneous injection of the remedy exercises on patches of the skin that have been affected by lupus, it was already mentioned, that after the subsiding of the swelling and reddening, the network of lupus does not resume its former condition, but that it is more or less destroyed, and disappears.

In separate spots, this may be seen by ocular demonstration to be effected by the morbid tissue absolutely dying after a single sufficient injection, when it is afterwards thrown off as a dead mass. In other places, a wasting, or rather a kind of melting away of the tissue appears to ensue, which for its completion, requires repeated applications of the remedy. In what manner this process is accomplished, cannot at the present moment be authoritatively determined, as the necessary histological investigations have not yet been made. So much, however, has been ascertained, that it is not a question of killing the tubercle-bacilli present in the tissue, but that only the tissue itself, in which the tubercle-bacilli are enclosed, is affected by the action of the remedy. In this tissue, as is shown by the visible swelling and reddening, considerable disturbances in the circulation occur; and with these, manifestly important alterations in the nourishing, which cause the tissue to die away more or less quickly and completely, according to the manner in which the remedy is put in action.

ACTION IN KILLING TUBERCULOUS TISSUE.

The remedy accordingly (once more briefly to repeat it) does not kill the tubercle-bacilli, but the tuberculous tissue. This fact, therefore, accurately defines the limit to which the activity of the remedy can extend. It is only able to affect living tuber-

culous tissue : on dead matter, for instance, dead caseous masses, necrotic bones, etc., it has no influence ; just as little does it affect the tissue that it has itself caused to die away. In dead masses of tissue of this kind, living tubercle-bacilli may yet lurk, and these are generally thrust away with the necrotic tissue ; but very possibly, under especial circumstances, they may again penetrate into the neighbouring and still living tissue.

It is especially this quality of the remedy that should be carefully noted, by those who would avail themselves of its healing qualities to the fullest extent. The still living tuberculous tissue must, in the first instance, be killed, and then every exertion must be made to get rid of the dead tissue as soon as possible, for instance, by surgical assistance ; but where such assistance is not possible, and the elimination can only proceed slowly by the curative process in the organization itself, the threatened living tissue must be protected, by a repeated employment of the remedy, from a return of the parasites.

From the fact that the remedy causes the tuberculous tissue to die away, and only acts upon the living tissue, another, and an extremely curious quality belonging to it is noticed—namely, that it can be administered in very rapidly increasing doses. At first it would seem natural to explain this phenomenon as arising from the patient's becoming habituated to the remedy. But when we learn that the increase of the dose within

about three weeks can reach an amount five hundred times the quantity originally administered, this cannot well be explained on the principle of habituation, as no analogous instance of such rapid adaptability to a powerfully-acting remedy can be cited.

This phenomenon will rather have to be explained by the fact that, at first, there is present a great quantity of tuberculous living tissue, and corresponding with this, a small amount of the active substance is sufficient to produce a strong reaction; but with every injection a certain amount of the tissue capable of reaction is made to disappear, and then, proportionally, larger and larger doses are necessary to obtain the same degree of reaction as before. Besides this, within certain limits, habituation may also exert its influence. So soon as the tuberculous patient has been treated with increased doses, until he exhibits only as much reaction as appears in one not suffering from tubercle, it may be assumed that all tuberculous tissue capable of reaction has been killed. Then the patient will only have to be supplied with gradually-increased doses, and the treatment to be continued, with intervals, so long as bacilli are still lurking in the system, to secure him against a fresh infection.

DESCRIPTION OF THE TREATMENT PURSUED.

Whether this explanation, and the deductions drawn from it, are correct, must be left to the future

to show. For the present they have only served to establish a method of constructing rules for the application of the remedy. According to our investigations the system of treatment was as follows :—

To recommence with the simplest case—namely, with typhus. In almost all cases of patients of this kind, we have begun by at once injecting the full dose of 0·01 cubic centimetres; then the reaction was allowed completely to run its course, and after one or two weeks the dose of 0·01 cubic centimetres was again administered, and this was continued until the reaction became weaker and weaker, and finally ceased altogether. In the cases of two patients suffering from lupus of the face, the lupous places were brought to the smooth cicatrised condition after three or four injections; in the other lupus patients, an improvement was produced, in proportion to the duration of the treatment. All these patients had been sufferers for many years, and had previously been treated in the most various ways, without any beneficial result.

In an entirely similar manner tuberculous diseases of the glands, bones, and joints were treated, large doses being administered, with considerable intervals between them. The result was identical with that in the lupus cases—namely, rapid cure in recent and lighter cases, and a slowly progressive amelioration in the graver ones.

The conditions were somewhat different with

the great mass of our patients—those suffering from phthisis. Patients with pronounced tuberculosis of the lungs are much more susceptible to the remedy than those suffering from surgical tuberculous affections. We were very soon obliged greatly to reduce the dose of 0·01 cubic centimetres, which had at first been fixed at too high a scale for consumptive patients, and found that in patients suffering from phthisis, a strong reaction almost invariably set in, even after a dose of 0·002 or only 0·001 cubic centimetres; but that from this small first dose we were able to advance, with more or less speed, to the same quantities that are well supported by the sufferers from other diseases. As a rule, we proceeded in such a manner that the phthisis patient first received 0·001 cubic centimetres, and that, when an increased temperature resulted, this dose was repeated once every day, until reaction no longer followed it. Not until then was the dose strengthened to 0·002 cubic centimetres, and thus continued until this quantity also produced no reaction; and thus we continued, always increasing the dose by 0·001 or at most 0·002 cubic centimetres, until it reached a strength of 0·01 cubic centimetres and beyond. This mild proceeding appeared to me especially requisite in the cases of patients whose strength was at a low ebb.

Where this method of treatment is followed it can be easily managed to bring a patient, almost without raising his temperature to fever, and almost

imperceptibly to himself, into the way of taking very strong doses of the remedy. A few phthisis patients, who still had a moderate amount of strength, were treated from the commencement with large doses, and others with doses very rapidly increasing in strength; and here the favourable result appeared to be proportionately more quickly obtained. The action of the remedy in consumptive patients usually manifested itself in this manner: After the first injections, coughing and expectoration were generally increased; but then they diminished more and more, and in the most favourable cases disappeared entirely; the expectoration also lost its purulent character, and became slimy. The number of bacilli (for only such patients were chosen for experiment in whose expectorations bacilli appeared) did not generally decrease, until the expectoration had assumed a slimy appearance. They then disappeared entirely for a time, but were met with again from time to time, until the expectoration ceased altogether. At the same time the night-sweats ceased, the general appearance of the patients was improved, and they increased in weight. Patients who received the treatment in the first stages of phthisis were all freed, in the course of four to six weeks, from every morbid symptom, so that they could be looked upon as cured. Patients in whose lungs the cavities were not very large, also considerably improved, and were almost cured. It was only in consumptive patients in whose lungs there were

numerous and large perforations, that no objective improvement was discerned, though the expectoration was decreased even in their cases, and their subjective condition was better. After these experiences I feel warranted in asserting that *incipient phthisis is to be cured with certainty by the remedy*. In a certain degree, this may also be true of other cases that have not advanced too far.

THE TREATMENT IN COMBINATION WITH OTHER METHODS.

Consumptive patients in whose lungs large cavities have been formed, and in whose cases complications have arisen, as, for instance, through the penetration of other pus-creating micro-organisms into the cavities, through pathological changes in other organs that can no longer be remedied, etc., will probably only in a few instances derive any

* This assertion certainly requires a limitation, in so far as at present no conclusive experience on the subject has been attained, or, indeed, can yet have been attained, as to whether the cure is a permanent one. Relapses are, of course, not to be excluded from the calculation. But it may be assumed that such cases could be as speedily and as easily combated as the first attack.

On the other hand, however, it may be possible, according to analogies drawn from other infectious diseases, that the patients once cured enjoy a permanent immunity. But this also must, for the present, remain an open question.

lasting benefit by adopting the remedy. Still, in most cases patients, even of this kind, were temporarily benefited. From this it must be concluded that, even with these patients, the original disease, tuberculosis, was affected in the same manner by the remedy as in the cases of the other patients, but that generally the defective point is the impossibility of getting rid of the masses of dead tissue and the secondary suppurating processes. Involuntarily the thought here arises, whether it would not be possible to benefit even some of these grievously sick persons, by a combination of the new remedial treatment with surgical practice (in the manner of operations for pyæmia) or in conjunction with other healing means. I would, moreover, seriously deprecate the application of the remedy in an empirical manner, and without distinction, in all tuberculous cases. As may be expected, the treatment will appear in its simplest form in the beginning of phthisis, and in simple surgical affections; but in all other forms of tuberculosis surgical science should be allowed its full rights, each case being carefully individualized, and all other remedial measures employed, to support the working of the remedy. In many cases I have had a strong impression that the nursing which the patients received had an important influence upon the working of the remedy;—I would, therefore, give the preference to the application of the remedy in suitable institutions, where a careful observation of the patients and careful

nursing of them can be best carried out, to the wandering or domestic application of it. How far the methods of treatment heretofore acknowledged as useful—the use of mountain air, of the “open air,” of specific diet, etc.—may be advantageously combined with the new method of proceeding, can at the present moment not well be estimated; but I think that these curative factors will be of considerable use* in connection with the new treatment, especially in severe and in neglected cases, and, further, in the stage of convalescence.

NECESSITY OF EARLY DIAGNOSIS.

The central point of the new remedial treatment lies, as we have said, in the earliest possible application of it. The first stage of phthisis should be the great object of the treatment, because in combating this stage, it can fully and completely display its powers. Therefore it can hardly be urged with sufficient emphasis, that in future, much more than has been usual heretofore on the part of practising physicians, every endeavour should be turned towards making the earliest possible diagnosis of phthisis. Until lately, the recognition of bacilli in the expectorations was looked upon rather as a not uninteresting minor circumstance, by which the diagnosis could indeed be confirmed, but

* With regard to brain, throat, and miliary tuberculosis, the material at our disposal was too limited to collect experiences on these subjects.

no further advantage was to be gained ; for which reason it was only too frequently omitted, as I have had reason to learn lately from a number of consumptive patients, who had usually passed through the hands of various physicians without having had their expectorations even once examined. In the future this must be altered. A physician who neglects to use all the means at his disposal, especially those afforded by an examination of doubtful expectorations, to ascertain the presence or absence of tubercle-bacilli, and thus to become aware, as early as possible, of the existence of phthisis, is guilty of a grave dereliction of duty to his patient : for the life of the patient may depend upon this diagnosis, and the mode of treatment at once adopted on the foundation of its result. In doubtful cases the medical man should, by a trial injection, procure for himself certainty as to the presence or absence of tuberculosis.

Then only will the new curative treatment have become a true blessing to suffering humanity, when things have been so far advanced, that as much as possible all cases of tuberculosis are taken in hand early, and things are not allowed to get so far as to the development of the neglected heavy forms, which until now have been an inexhaustible source of new infection.

In conclusion, I would still remark that in this address I have purposely omitted the statistical enumeration and delineation of separate cases of disease, because those physicians, from among

whose patients the sufferers were chosen, on whom our observations were made, have themselves undertaken to describe the cases, and I did not wish to anticipate them in a description of their observations, that should be as objective as possible.

DISTRIBUTION OF PULMONARY CONSUMPTION.

To form a just estimate of the extraordinary influence which the discovery of Robert Koch will have, not only on the knowledge of the healing art but on the welfare of the public at large, it is in the first place necessary rightly to appreciate the diffusion of that devastating disease, and the number of its victims, both of which points have been verified by statistics. By placing these side by side with the results that may be expected in the future under the influence of Koch's remedial system, every reader will be put in a position fully to understand the greatness and significance of this latest discovery in medical science.

Pulmonary consumption is a disease that is diffused in a greater or less degree over the whole earth. But it has been proved that in elevated regions, at an altitude of 1700 to 2000 feet or more, the disease occurs far less frequently than in the plains. Thus, for instance, in the Rhöngelbirge,*

* A range of mountains in Germany, on the frontier of Bavaria.

we find remarkably few instances of consumption in contrast with the number in the lowlands. This is seen still more distinctly in the Alps, and most manifestly of all in the high-lying districts of the tropical latitudes. The opinion formerly held, however, that pulmonary consumption is of more frequent occurrence in a cold than in a warm climate, has not been confirmed by experience; and the immunity from consumption enjoyed by places situated within the tropics can accordingly only be explained by the circumstance, that in those regions places are habitable, situated at a great distance above the sea-level, where at a corresponding altitude in the temperate zones no inhabitants would be found. Thus, on the Andes range, at an elevation of 2000 to 3000 metres (6500 to 9800 feet), pulmonary consumption is almost entirely unknown, while in the plains situated close by the mountain range, a large percentage of the mortality is due to this cause. Professor August Hirsch, one of the greatest authorities on the geographical diffusion of epidemic and other diseases, explains this fact by the assertion that the rate of respiration (the number of breaths drawn within a minute) being greater in lofty regions than in the plain, causes, by the more frequent and energetic expansion and contraction of the lungs, a kind of involuntary gymnastic exercise of those organs, by which any predisposition to phthisis that may be present is destroyed. On the other hand, Hirsch denies that the average temperature arising from

the geographical and territorial position of a place has any influence on the existence and the more or less frequent appearance therein of pulmonary consumption. Indeed, in very hot, especially in intertropical districts, the course of the disease is more rapid and malignant than in higher latitudes. On the other hand, a long series of experiences will vouch for the fact that a large amount of moisture in the atmosphere will bring about a favourable condition for the production of consumption, while those regions that are free from consumption generally exhibit a remarkable dryness in the air, or, with a medium amount of moisture, have a very equal temperature.

STATISTICS OF MORTALITY FROM CONSUMPTION IN GERMANY.

A peculiar phenomenon is noticed in the hereditary nature of consumption; yet it is not the disease itself that is hereditary, but only the tendency, the predisposition to it. This predisposition arises from a certain weakness in the structure of the lungs. They are imperfectly developed, and occupy a smaller space than usual; the capacity of the chest is seen to be remarkably narrow—it is flat, and at the same time abnormally long.

Besides this inherited tendency to consumption there is undoubtedly an acquired one; frequently the hereditary predisposition is increased by certain noxious influences. Among these influ-

ences the first is found in defective, insufficient, and improper food; and in this category, the feeding of infants with bad milk, gruel, and similar messes, may be instanced; further, the abiding for a long time in a badly ventilated atmosphere, that is filled with decomposing particles. This latter cause of injury is especially seen in the cases of criminals, who live for years in prisons; a large percentage of these fall sick of pulmonary consumption. Labourers amid dust particles, especially those who inhale metallic dust (file-cutters, grinders, stonecutters), and workers in cotton factories, also furnish a higher contingent to the ranks of phthisical patients, than other working people. Finally, the predisposition to consumption is increased by the weakening of the system through sexual excesses, and also through sorrow, and exhausting illnesses.

The disease becomes more frequent with the spread of civilization. In proportion as certain regions of America became more densely populated, and the simple modes of life made way for more civilised ones, cases of pulmonary consumption increased. Communities that live crowded together, especially therefore the inhabitants of large cities, are greater sufferers from the disease than the rural population; and here, on the one hand the bad air, and on the other the excessive increase of the destitute classes, probably contribute to increase of the number of cases of consumption.

*AMOUNT OF MORTALITY FROM
CONSUMPTION.*

We now turn to the consideration of the statistics of mortality from pulmonary consumption, and are startled by the abnormal height of the numbers with which we are brought face to face.

The mean average of deaths for the whole population annually amounts to three per cent. The average of deaths from pulmonary consumption is twenty-two in the thousand. Accordingly one-seventh of the total of deaths from all causes is due to this one disease, so that *one-seventh of the human race perishes by tuberculosis.*

Concerning the mortality from pulmonary consumption in Prussia, we take the following particulars from recent statistics published by the "Vossische Zeitung":

In Prussia in the year 1882, 85,859 persons died of consumption; in 1883, 88,837; in 1884, 87,756; in 1885, 88,056; in 1886, 88,283; in 1887, 84,124; and in 1888, 84,109. In the last seven years, concerning which returns have been made, 606,524 persons have accordingly fallen victims to this disease. The male sex furnish a far higher proportion of these cases than the female, although, as is well known, the female population is more numerous than the male, among the inhabitants generally. In each separate year, from 5000 to 7000 more men than women succumbed to this malady. In 1887 its victims were 45,529 men and

38,595 women; and in 1888, 44,845 men and 39,264 women. The numbers for 1887 and 1888 are, it will be noticed, somewhat smaller in general than those of the former years; and this improvement has additional importance, when the increase of population is considered, that occurred in the meantime. In 1886, out of 10,000 of the living male population, 34·19 died of consumption; in 1887, 32·35; in 1888, 31·42; and out of the same number of the living female population, 28·20 died of consumption in 1886; 26·42 in 1887; and 26·52 in 1888. But the fact must be taken into consideration, that the general mortality has greatly decreased in the two last-mentioned years, so that the proportion of those who died of tuberculosis, when compared with the whole number of deaths, has not much altered. In 1887, among the males who died, 12·72 per cent. fell victims to tuberculosis; in 1888, 13·00 per cent.; and of the females who died, 11·76 per cent. and 12·25 per cent. respectively.

In dividing the population into classes, with respect to different periods of life, the greatest divergences are met with in the statistics of mortality from tuberculosis. The significance of this disease increases marvellously, as the classes advance from one period of life to another. Thus, in 1888, among 100 persons of the male sex who died between 10 and 15 years of age, already 16·08 deaths were due to this disease; and of 100 deaths in the class between 15 and 20 years, 39·66 were

from consumption. In the next class, comprising persons of from 20 to 25 years of age, 47·68 per cent. of the male deaths were due to tuberculosis; and *in the class between 25 and 30 years, 44·16 per cent., accordingly nearly one-half of the total number of deaths.* After this period the virulence of this terrible disease decreases. In the total of deaths of persons between 30 and 40 years, 40·33 per cent. are due to this disease; of those between 40 and 50 years, 34·95 per cent.; between 50 and 60 years, 28·16 per cent.; between 60 and 70 years, 18·32 per cent.; between 70 and 80, 5·94 per cent.; and above 80 years, 1·12 per cent. With regard to the female sex, the remarkable fact is shown that tuberculosis exerts its chief power at a much earlier period of life than with men. In the age between 10 and 15 years, already 25·52 per cent. of all deaths among females were due to consumption; between 15 and 20 years, the maximum came with 46·47 per cent., therefore ten years earlier than among the males; then the numbers keep up, for the class between 20 and 25 years to 46·01 per cent., and for the age between 25 and 30 years to 44·79 per cent.; then they decline for every ten years of life to 40·10 per cent., 32·67 per cent., 24·33 per cent., 14·62 per cent., 4·22 per cent., and 0·82 per cent. respectively.

STRIKING VARIATIONS IN VARIOUS LOCALITIES.

If we trace these figures through the different parts of the country, striking differences will here also be found. Tuberculosis is most prevalent in the western and north-western parts of the kingdom, and gradually decreases towards the east, in such a remarkable degree that in the most favourable districts it does not give rise to a third part of the mortality it occasions in the most unfavourable ones. Thus, in 1888, consumptive persons were represented among the deceased in the government districts:—Of Osnabruck, by 22·9 per cent.; of Munster, 22·2 per cent.; Arnsberg, 19·8 per cent.; Düsseldorf, 19·7 per cent.; Minden, 18·5 per cent.; Cologne, 18·4 per cent.; Coblenz, 17·9 per cent.; Wiesbaden, 17·3 per cent.; Treves, 16·4 per cent.; Aurich, 16·3 per cent.; Hanover, 16·2 per cent.; Stade and Aix la Chapelle, 16·1 per cent.; the city of Berlin, 15·4 per cent.; Schleswig, 14·8 per cent.; Lüneburg, 14·3 per cent.; Breslau, 12·2 per cent.; Sigmaringen, 12·0 per cent.; Stralsund, 11·7 per cent.; Cassel, 11·4 per cent.; Oppeln, 10·9 per cent.; Magdeburg and Erfurt, each 10·7 per cent.; Hildesheim, 10·4 per cent.; Frankfurt, 10·1 per cent.; Stettin and Posen, each 9·9 per cent.; Potsdam, 9·4 per cent.; Köslin, 8·5 per cent.; Merseburg, 8·4 per cent.; Bromberg, 7·5 per cent.; Gumbinnen, 7·3 per cent.;

Dantzig, 7·2 per cent. ; and, finally, Königsberg and Marienwerder, each with 6·8 per cent.

In drawing distinctions also between country districts and towns very considerable differences are found to the disadvantage of the latter. Thus, in the year 1888, 11·9 per cent. of deaths were ascribed to tuberculosis in the open country, and 13·8 per cent. of the deaths in towns. If the towns are further divided according to the number of their inhabitants, into "small towns" (with 20,000 or fewer inhabitants), "medium-sized" towns (with 20,000 to 100,000 inhabitants), and "great towns" (with more than 100,000 inhabitants), it will be found that tuberculosis carries off in the small towns only 12·7 per cent., in the medium-sized towns 14·7 per cent. among those who die, while in the great towns it is accountable for 15·2 per cent. among all the deaths. The number accordingly increases with the increased size of the towns ; still the difference between medium-sized and great cities is not very important. Moreover, the twelve great cities do not rank with regard to the prevalence of consumption, in the order of their size, but in the following order: In Königsberg, 8·9 per cent. of the entire number of deaths were caused by tuberculosis ; in Dantzig, 9·0 ; in Magdeburg, 12·5 ; in Cologne, 14·9 ; in Berlin, 15·4 ; in Altona, 16·0 ; in Hanover, 16·6 ; in Breslau, 16·7 ; in Düsseldorf, 17·2 ; in Elberfeld, 17·5 ; in Frankfort-on-the-Maine, 18·9 ; and in Barmen, 20·9 per cent. Thus

here also, in a general way, the diminution towards the east became manifest.

COMPARISON OF STATISTICS OF COUNTRY AND TOWNS.

Another fact, in itself remarkable, is that the greater liability of the male sex to be attacked by consumption is less marked in the country than in the towns, and that it rises rapidly with the increased size of the towns. In the country, among those who died of consumption 49·0 per cent. were of the female and 51·0 per cent. of the male sex, in the small towns 55·1 per cent. of males to 44·9 per cent. of females, in the medium-sized towns 56·7 per cent. males to 43·3 per cent. females, in the great towns 58·6 per cent. of males to 41·4 per cent. of females, and in Berlin even 60·6 males as against 39·4 per cent. of female victims. Consequently in the great towns men succumb to the influences of tuberculosis much more readily than women.

According to the statistics of mortality given above, the number of cases of death by pulmonary consumption varies in Prussia between 84,000 and 88,000 annually.

As the tubercle-bacilli not only produce pulmonary consumption, but are also the cause of a number of tuberculous diseases of other organs, for instance of intestinal tuberculosis, of lupus, and tuberculous inflammation of the joints, which so-

called local tuberculosis also causes a number of deaths every year, it follows from this that *in Prussia in every year, nearly 90,000 persons are destroyed by tuberculosis.*

Respecting the statistics of mortality by pulmonary consumption specially relating to the city of Berlin, the treatise furnished by the city to the Tenth International Medicinal Congress gives us information. The rate of mortality expressed as the rate per thousand, here amounts to 121·29 per thousand among the male, and only to 90·25 per thousand among the female population—84 out of a thousand men die between the ages of 25 and 60 years, while among the women the period between the age 20 and 45 years seems especially fraught with peril, furnishing 52 deaths for every thousand persons. The only class of diseases that furnish a higher number of deaths are the fluxial diseases of every description which lead to 125·53 deaths in a thousand in the male sex, and 115·64 per thousand among the female sex, but of these 107·42 in the male and 98·71 in the female sex are deaths of children under one year of age. *Next to diarrhæa, accordingly, in Berlin pulmonary consumption causes the greatest amount of mortality.*

SUMMARY OF PROFESSOR KOCH'S OBSERVATIONS.

Let us set against these gigantic figures the simple and modest words of Koch: "*According to*

these experiences, I would assume that incipient phthisis is to be cured by the method, and the fact that persons suffering from disease of the lungs, where the tissue of the lungs had not been too much destroyed, derived great benefit, and were almost cured." Then the enormous significance of Koch's discovery for the welfare of the whole human race at once presents itself to every mind. Mortality will decrease more and more in the case of just that disease, which until now has furnished death with the greatest number of victims. Human beings, unlike those who were snatched away in the best years of life, will now be preserved to existence, to their families, and to labour; as one-seventh of the human race will no longer perish by pulmonary consumption, the general total of mortality will decrease; and thus, indirectly, *a general lengthening of the duration of human life will be brought about.* The unsatisfactory medical treatment of consumption has given place to a deliberate well-considered method of action, and therapeutic science will no longer fail in consequence of social inequalities; but all, whether rich or poor, will be participators in the blessings of this wonderful discovery.

But still further prospects of wonderful brightness open for the future. Why should what has succeeded in one infectious disease, since there is nothing in principle to stand in the way, not be possible in the case of other diseases? And so we will hope on, in expectation that the words with

which Koch himself concludes the address he delivered before the International Medicinal Congress may be verified to the good and blessing of mankind.

"But if the hopes that further attach themselves to these attempts be fulfilled, and should it become practicable, in the first instance in a bacterial infectious disease, to subdue the microscopic, but till then overmastering enemy in the human body itself, I do not doubt but that the same victory will be achieved in other diseases. With this a very promising field of labour is opened, with tasks that are worthy of being the objects of an international competition of the noblest kind."

ROBERT KOCH'S CAREER.

A BIOGRAPHICAL SKETCH.

ROBERT KOCH was born at Clausthal in 1843, the son of an official of some position in the Department of Mines. After receiving preparatory instruction in the school of his native place, he went in 1862 to study medicine at the university of Göttingen, where he completed his course in 1866. Among the teachers at whose feet Koch sat in the "Georgia Augusta," was one who in scientific importance towered above all the rest—the anatomist, Jacob Henle. We can scarcely be wrong in asserting of Henle that he had an especial influence on the subsequent activity of Koch; at all events, in his system of modern pathology there appears one of the earliest expressions of the fact that now stands in the focus of medicinal science—the recognition that the cause of infectious diseases is to be sought in the life system of plants. Moreover, a fellow-labourer

with Koch, Flügge, has given public expression to this connection of Henle's with modern bacteriology, by dedicating his handbook on this subject, the best among all works of the kind, to the memory of Henle.

After passing the government examination, Koch was for a time assistant-physician in the general hospital at Hamburg, and then commenced practice on his own account. He began at Langenhagen in Hanover ; afterwards, his activity was transferred to the little town of Rackwitz in Posen, from whence he went as medical officer for the Bomst district, to another small place called Wollstein. Medical practice in the little town was not exactly calculated to promote scientific investigation, for which purpose, such aids are generally required as are found in well-furnished laboratories, in the counsel and criticism of men who understand the subject, and, lastly, in the possession of sufficient leisure. All this was wanting to Koch in Rackwitz and Wollstein. Though engaged in a practice which obliged him to travel day by day, and often in the night time, too, in a clumsy vehicle, long distances over frequently rugged roads, Koch still pursued scientific investigations with such seriousness and zeal, that the first result which he made public procured for him, the simple country doctor, an honourable position in science. This work consisted of observations on mortification of the spleen, and so completely elucidated the course and diffusion of

this disease, as scarcely to leave an open point in its history.

An external circumstance furnished the reason for Koch's giving publicity to this subject in 1876. A year before, Ferdinand Cohn, the celebrated Breslau botanist, had given notice of discoveries, made in connection with this disease of the spleen. Similar knowledge on the subject, that went far beyond Cohn's discovery, had been attained quite independently by Koch, who was consequently anxious to have his results tested by a master in the investigation of fungi, like Cohn. With this object, early in the summer of 1876, Koch called at the Botanical Institute at Breslau, in order to exhibit there, before the eyes of acknowledged proficients in the subjects, the discovery he had made, and to explain the way by which he had arrived at it. Besides Cohn and his assistant Eidum, there belonged to this remarkable scientific institute the pathologist Ludwig Cohn, Karl Weigert, who is now at Frankfurt-on-the-Main, Ludwig Lichtheim, now professor at Königsberg, and the anatomist Auerbach. All these were convinced, before Koch had even ended his demonstration, that they had here to do with a discovery of the greatest significance. Koch's investigations, of which the central point is the proof of the propagation of spleen bacilli by means of spores, were published in the second volume of Cohn's "Contributions to the Biology of Plants," under the title "The Œtiology of Mortification of

the Spleen, founded on the History of the Development of the Bacillus Anthracis." Only by casual remark, in which Koch speaks of blood from a diseased spleen that he had kept by him for five years, was it to be seen that this treatise gave the result of the work of years. The same volume of contributions contains a second study of Koch, "Proceedings for the Investigations for the Preserving and Photographing of Bacteriæ," in which we see Koch busily employed, using his best efforts by the use of the technics of colour, to bring order into the chaos that still existed on the subject of the nature of bacteriæ.

The promise of these first studies was fulfilled in the later writings with which Koch came forward two years afterwards. They were "New Investigations on the Micro-organisms of Infectious Wound-diseases," of which Koch first gave intelligence in the united inner and pathological section of the Naturalists' Union at Coblenz. What Koch communicated was not less important than his studies on. He has succeeded in demonstrating, with respect to a whole series of artificially-produced wound-diseases in animals, that they have their origin in most decided micro-organisms, and each one, in fact, in a separate kind—a demonstration which brought the wonders of the Listerian method of antiseptic treatment of wounds much nearer to scientific principles. Koch won this result by means of the latest facts gained by microscopic research, and by the judicious use of

the technics of colour, and by "Oil-immersion" and "Abbé's Condensor," both of which, in the meantime, have, through Koch alone, fully acquired their right of citizenship in medical science.

A man who had produced such works could not well remain in the isolated position of a country practitioner; but at the time no appropriate sphere of action could be found for him.

It was not until 1880—and, according to W. Kühne's account, it was not accomplished then without the influence of Cohnheim—that Koch was put into his proper position, when he was summoned to Berlin to take the place of Professor Finckelnburg, who returned to his professorship at Bonn, as a member in ordinary, having already been an extraordinary one. Here, in possession of adequate scientific appliances, and at the same time in continual intercourse with well-informed scientific men, Koch displayed, in a double sense, a very beneficial activity in one direction as an investigator, in another as a teacher.

An epoch was marked in medical science by his discovery of the tubercle-bacillus—a discovery which Koch first made known in March, 1882, in the Berlin Physiological Society. It threw a clear light upon the obscure chapter of tuberculosis, so that the scientific dispute regarding the nature and extent of that disease—which had not rested since the time of Baillie and Bayle—was definitely settled. Koch showed that lupus of the skin, scrofulous and fungous inflammation of the joints, miliary

tuberculosis, tuberculosis of the lungs in its exceedingly varied forms, tuberculosis of the internal organs, and of the bones (to speak here only of one class of diseases of mankind); that all these are generically related to one another, and that they have their origin in a bacillus, which causes the formation of tubercle. He demonstrated that this bacillus occurs in all tubercular diseases, and only in these; he showed that it can be isolated and treated independently, and how it is possible, by culture of this bacillus, to produce tuberculosis artificially in animals; and all this Koch proved so clearly and completely that there was not anywhere the smallest break in the whole chain of his demonstration. Koch produced his investigations of the ætiology of tuberculosis in a form that was complete to the minutest detail, so that no one else has been able to add anything material to it; although, for example, Ehrlich has facilitated the recognition of bacilli by simplifying the technical form. Only two or three investigators, indeed, have undertaken the task of repeating Koch's laborious mode of procedure; among them is Baumgarten, who, simultaneously with Koch, but independently of him, had recognised the tubercle-bacilli.

The year 1883 brought new labour and new results for Koch! After a period of rest of ten years, the confines of Europe were once more threatened by the spectre Cholera. From Damietta came, in 1883, the news of the breaking out of the

pestilence, which quickly spread abroad over the whole of Egypt. The German Government considered it prudent to send out a competent commission to make observations on the cholera. No one but Koch could be the leader of this detachment, for by the light he had thrown upon the ætiology of tuberculosis, he had shown himself to be the real and true investigator of infectious diseases.

On the 16th of August, 1883, the commission started for Alexandria. While it was working zealously in that place, the cholera disappeared in Egypt before the chief object for which the men of science had been sent out, the ascertaining of the cause of the disease, had been achieved. Koch accordingly obtained from the German Government the permission to proceed, with his staff, onward to India, the old hearth of cholera, there further to pursue the work begun under the best auspices. Here the great cast was successful. Koch observed, in the first place, that in all cases of cholera there is found, in the evacuations of the patients, and in the contents of the intestines of those who have died, a bacillus which, with regard to its shape and its peculiarities of existence, can be accurately distinguished from all known micro-organisms. To these observations Koch was able to add the fact that this bacillus makes its appearance in cholera cases and in no other kind of disease, and that its connection with cholera is so close, and constituted in such a manner, as to warrant its being set down as a cause of the scourge.

In short, Koch proved the existence of a new bacillus—he called it, from its peculiar shape, the “comma-bacillus”—which was in the most unqualified manner to be designated the exciting agent of cholera. By this discovery a problem had been solved, that for two generations, since the cholera first invaded Europe in the year 1829, had seriously occupied alike the medicinal faculty and the government authorities. But the increase of scientific knowledge, as such, was not all that Koch brought back with him, when, in the beginning of May, 1884, he returned from India to Berlin. He had also collected valuable experiences as to the best method of meeting, by practical measures, any new outbreak of cholera beyond the confines of its Indian home.

Because these experiences of Koch's, and the conclusions he deduced from them, were not in accordance with the views that had been until then entertained as to the nature of the cholera poison, he was involved in a controversy with Pettenkofer, the “senior master” of German hygiene, the champion of the older views; and this dispute has attracted a great amount of public attention. As an Areopagitic Council sitting in judgment upon the scientific dispute, the second cholera conference appeared. It was held in May, 1885, under the presidency of Virchow, in the offices of the Imperial Health Department. The first news of the discovery of the comma-bacillus was given by Koch from India, in official reports to the Imperial Chancellor,

which came to the knowledge of the public through the "Reichsanzeiger" (Imperial Gazette). The publication of a detailed account of the journey was left by Koch to his fellow-labourer, Dr. Gaffky, who, about two years since, brought the honourable task to a conclusion, in a work that forms a handsome quarto volume.

With what rejoicing Koch's discovery was hailed, not only by the medical world, and what honours were awarded to the learned scientist, is fresh in the remembrance of all. From that time Koch, the discoverer of the tubercle-bacillus and the comma-bacillus has been numbered among the most representative men of science in Germany; he, the modest man of learning, who is reluctant to step out upon the market-place, and is most happy when engaged in the diligent and quiet labours of the laboratory.

But the clearing up of the ætiology of mortification of the spleen, and of infectious wound-diseases, and the discovery of the tubercle-bacillus and the comma-bacillus, are only the chief of Koch's achievements; with them are associated other services, not indeed equal to those in greatness, but still exceedingly important in themselves, and naturally standing in close combination with those achievements. In the first place, it may be asserted that the whole system pursued in the modern investigation of bacteriæ was created in all essentials by Koch; the contributions made by others have only completed and widened Koch's

structure in separate points and in details ; in its origin it all goes back, more or less, to Koch himself. For it is precisely to his pupils that we owe in many ways the improvement of the bacteriological method, and the increase of bacteriological knowledge. Furthermore, among the separate studies of Koch, there must be taken into consideration his investigations into protective inoculation against mortification of the spleen, his observations on disinfection, on water and water supply, and in these last years his experiments on apes, respecting recurrent transmission, and his clever criticism of Nägeli's theory.

Since the autumn of 1885 Koch has been professor in ordinary of hygiene and bacteriology in the University of Berlin ; but long before he was summoned to this office, Koch had been productively active as a teacher, without being under any necessity thereto, by his position. It came about in the following manner : When Koch had made known his fundamental methods of bacteriology, the desire manifested itself spontaneously in the medical faculty that these important methods should be spread abroad. At the same time it was advantageous to Koch to train up for himself efficient assistants. The first opportunity in this direction of founding a school of his own was afforded to Koch, when, in 1880, as Councillor of the Imperial Office of Health, he was entrusted with the direction of the laboratory of that department. Thus the laboratory of the

Imperial Office of Health became the first seminary for bacteriological experiments according to Koch's method. From this institution the majority of the present bacteriological investigators of repute have gone forth.—From among the former assistants of Koch mention may here be made of Loeffler, Hüppe, Gaffky, Schill, Becker Bernhard Fischer, Gaertner, Plagge, Weiszer, Riedel, Paak. It was mostly from their ranks that the new-founded professorships of hygiene were afterwards filled.

A broader field for Koch's teaching activity was prepared when he was appointed professor of the University. He became the president of an independent Hygienic Institute, to which the old "Gewerbe Academie" was assigned as a home. The plain grey structure will doubtless be contemplated with a thankful spirit by succeeding generations, as the place where the means of remedy was invented, against the devastating scourge, for the benefit of humanity at large.

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THE END.

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